VOLUME XIII NUMBER 10

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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Victoria, B.C.

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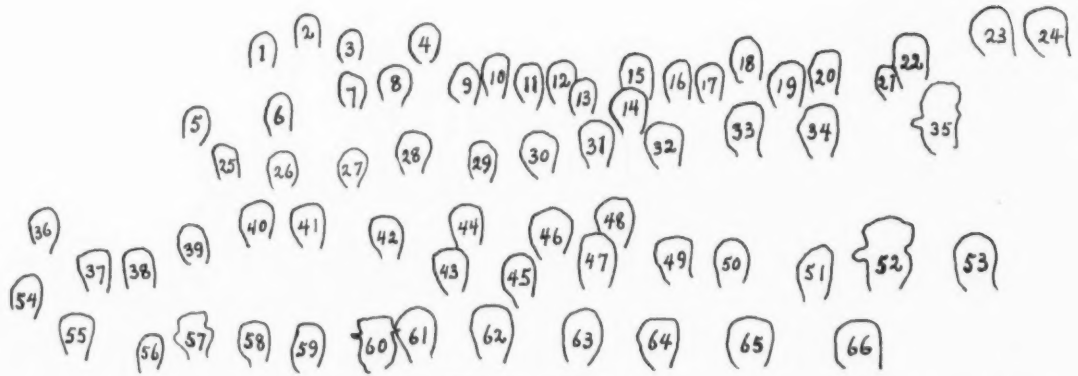
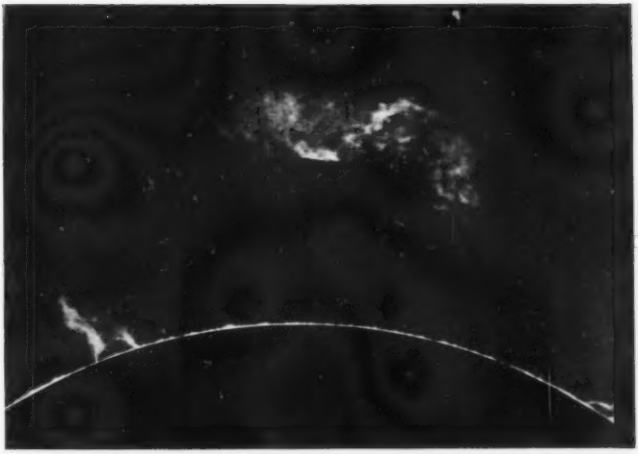


KEY TO PLATE V.

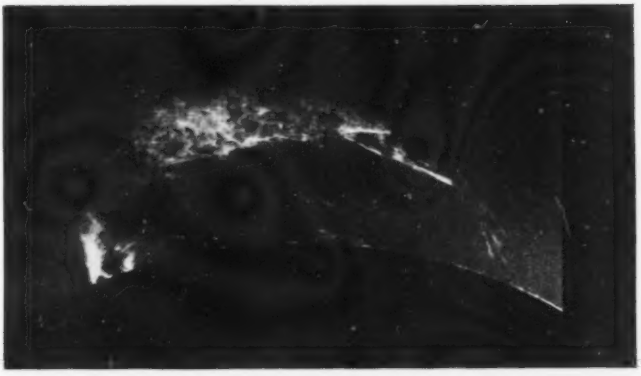
1. Chant. 2. Coggshall. 3. Rigge. 4. Paraskevopoulos. 5. Fath. 6. Douglass. 7. Henroteau. 8. Eichelberger. 9. Crump. 10. Lee. 11. Frost. 12. Pettit. 13. Bauer. 15. Peterson. 16. Brasch. 17. Rufus. 18. Leland. 19. Smith. 20. Hobbs. 21. Mrs. Marshall. 22. Lunn. 23. Stebbins. 24. Curtiss. 25. Peters. 26. Kiess. 27. Mrs. Kiess. 28. Miss Wickham. 29. Miss Farnsworth. 30. Mrs. Klotz. 31. Miss Bigelow. 32. Miss Young. 33. Miss Furness. 34. Klotz. 35. Miss Glancy. 36. Pawling. 37. Mrs. Moulton. 38. Moulton. 39. MacMillan. 40. Bailey. 41. Warner. 42. Miss Block. 43. Dugan. 44. Hussey. 45. DeLury. 46. Mrs. Hussey. 47. Van Briesbroeck. 48. Urie. 49. Sollenberger. 50. Mrs. Lunn. 51. Mrs. Pettit. 52. Miss Cannon. 53. Albrecht. 54. Miss Moulton. 55. Slipher. 56. Mrs. Roe. 57. Roe. 58. Howe. 59. Lord. 60. Tatlock. 61. Comstock. 62. Barnard. 63. Brown. 64. Miller. 65. Mrs. Miller. 66. Schlesinger.

PLATE VI.

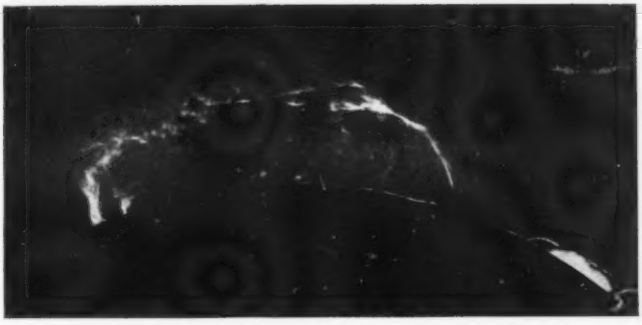
c
G. M. T.
$5^h\,32^m41^s$
Ht. 320,000
km.



b
$2^h\,56^m56^s$
Ht. 220,000
km.

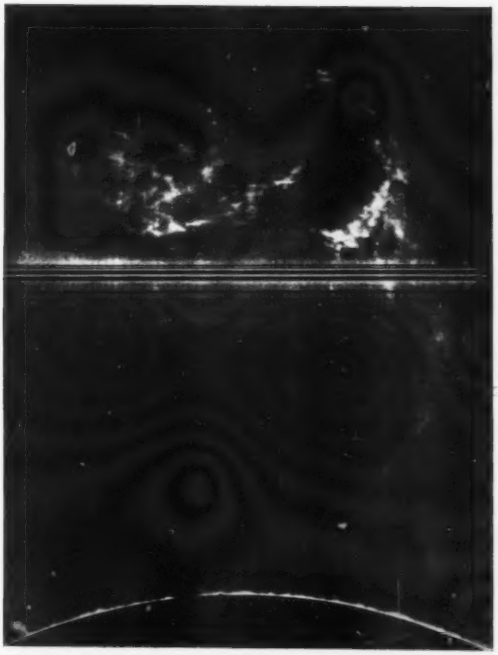


a
$1^h\,41^m16^s$
Ht. 200,000
km.

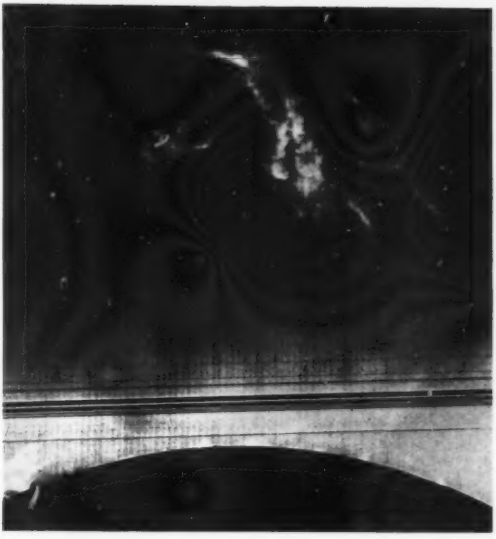


The Great Prominence of May 29, 1919.
Scale: for *a*, 1 mm. = 9326 km.; for *b* and *c*, 1 mm. = 8416 km.
(From the *Astrophysical Journal.*)

PLATE VII.



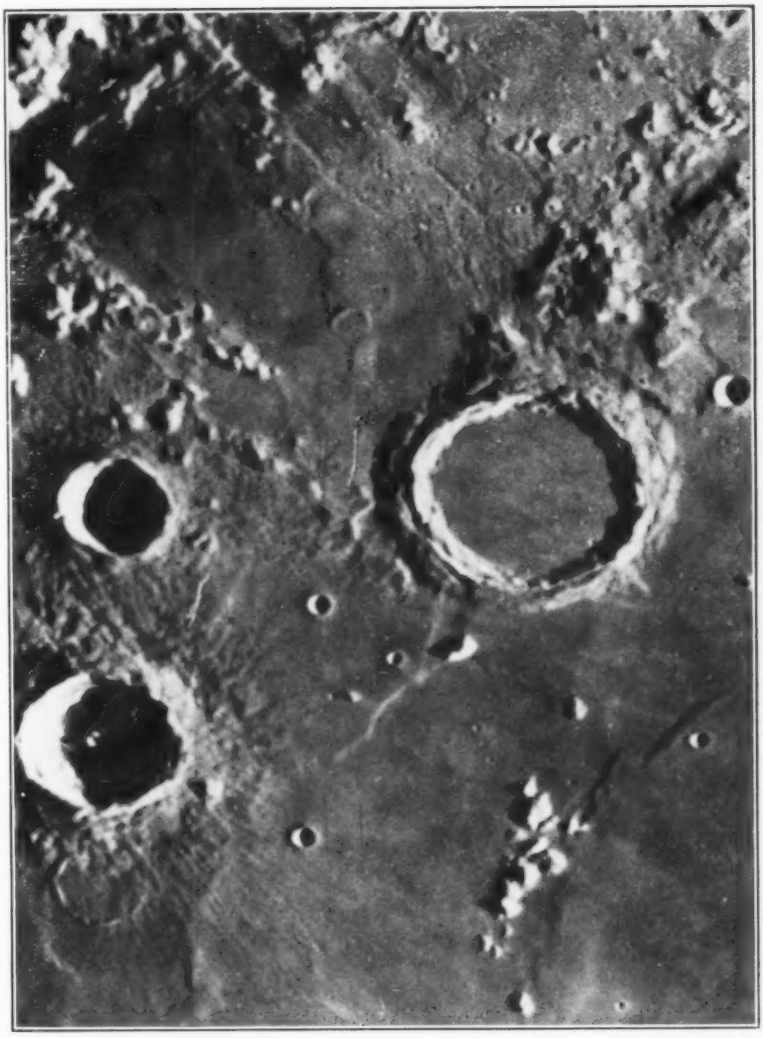
e
G. M. T.
$7^h\ 57^m 22^s$
Ht. 660,000
km.



d
$7^h\ 19^m 31^s$
Ht. 520,000
km.

The Great Prominence of May 29, 1919.
Scale 1mm. = 8416 km.
(From the *Astrophysical Journal.*)

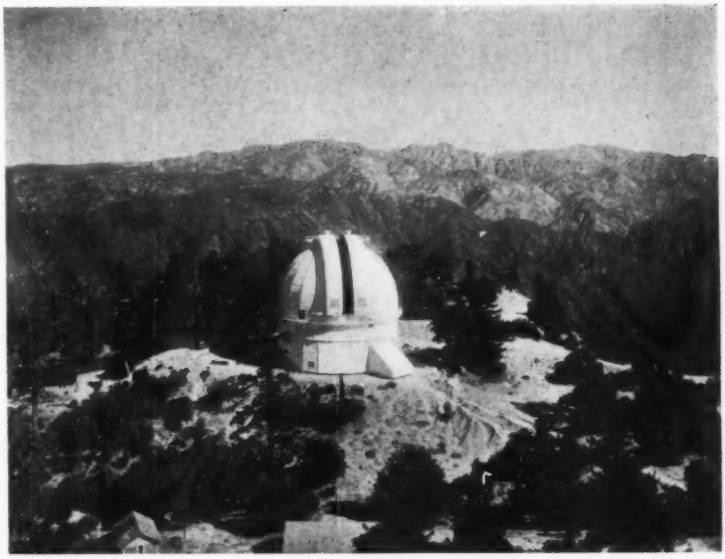
PLATE VIII.



Photograph of a portion of the moon taken with the 100-inch Reflector at Mt. Wilson Observatory; equivalent focus=134 ft. (The large crater is *Archimedes.*)

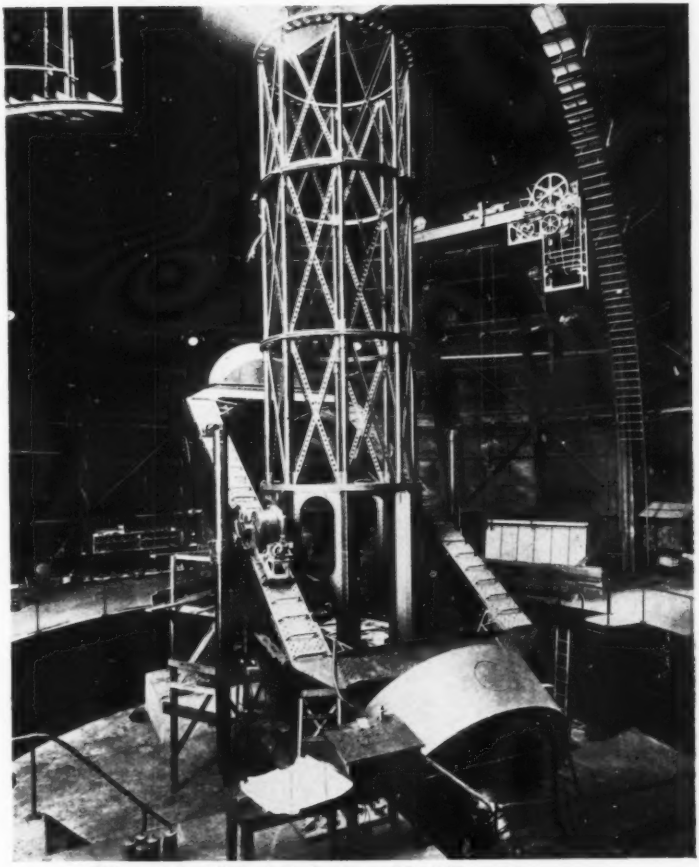
Journal of the Royal Astronomical Society of Canada.

PLATE IX.



Dome of the 100-inch Reflector.
(From the *Publications of the Astronomical Society of the Pacific.*)

PLATE X.



View of the 100-inch Reflector at Mt. Wilson Observatory.
(From the *Publications of the Astronomical Society of the Pacific.*)

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THE TWENTY-THIRD MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY

BY RALPH E. DE LURY

THE American Astronomical Society, and also the American Mathematical Society and the Mathematical Association of America, held meetings this year, September 2-5, at the University of Michigan, Ann Arbor. Accommodation was provided at the Helen Newberry Residence and at the new Michigan Union, for those attending the meetings of the societies. The university authorities and members of the staff also kindly arranged receptions, smoker, luncheon, dinner, motor drive about Ann Arbor, and inspections of the buildings, and the collections of old and curious musical instruments, old manuscripts and books relating to mathematics and astronomy.

On Monday evening, September 1, the Council of the Astronomical Society met at the Detroit Observatory. On Tuesday, morning and afternoon, sessions were held for the presentation of papers. Acting-President Schlesinger was chairman, and in opening the sessions paid tribute to the late Edward C. Pickering who had been President of the Society for the past thirteen years until the time of his death. The resolution passed by the Council shortly after his death on February 3, 1919, was ordered to be printed in the Publications of the Society. The Society had also

suffered in the loss of Charles L. Doolittle, who had been its first treasurer, 1899-1912. In the evening Professor and Mrs. Hussey held a delightful reception for delegates and friends; and later the observatory was inspected, the 37-in. reflector attracting particular attention.

On Wednesday, in the morning there was a meeting of the Council followed by a session for papers (Chairman, Dr. Schlesinger). At luncheon the members and their friends enjoyed the hospitality of Professor and Mrs. Hussey at their observatory home, after which the group photographs were taken (Plate V.) During the afternoon another session for papers was held (Chairman, Dr. Klotz). In the late afternoon there was an inspection of the huge Hill Auditorium and other buildings, the collection of musical instruments, etc.; and in the evening, a joint smoker with the mathematical societies was held in the Club Rooms, Alumni Memorial Hall, and a reception for the ladies at the residence of Professor and Mrs. Markley.

On Thursday morning, after the Council had met, another session for papers was held (Chairman, Dr. Schlesinger). A complimentary luncheon was tendered the societies in the Michigan Union. In the afternoon a joint meeting was held with the mathematical societies, at which President Slaught of the Mathematical Society presided. At this meeting Professor E. V. Huntington, retiring President of the Mathematical Association, delivered an address on "Mathematics and Statistics". Also, Messrs. Schlesinger, Stebbins and Bauer reported on the Brussels conference of scientists, and E. W. Brown on the work of the National Research Council (U.S.) with reference to mathematics and astronomy. After this meeting the members were given an enjoyable motor drive about Ann Arbor. In the evening a joint dinner was held with the two mathematical societies, Professor Slaught presiding. He acknowledged the kind welcome extended to the societies by Resident Regent Beal and Professor Beman who represented the university authorities and staff. Entertaining speeches were made and fine yarns spun by Messrs. Schlesinger, Stebbins (who spoke on incidents relating to the Brussels conference), Eisenhart, Rietz, Klotz (who recalled the past at Ann Arbor and made acknowledgment on behalf of the goodly number of Canadians present), and Hedrick (who told of the work and difficulties of the army colleges

in Europe and discussed the educational problems arising as a result of the war). Dr. Klotz also introduced the following resolution which was unanimously adopted: "The American Astronomical Society, the American Mathematical Society, and the Mathematical Association of America desire to express their appreciation to the University of Michigan for its hearty co-operation in the successful carrying out of our meetings and deliberations. We deeply recognize the hospitality that has been extended to us which has added so much to the enjoyment of our stay in Ann Arbor."

On Friday morning, September 5, after the meeting of the Council, the Astronomical Society held its final session for papers and for the election of officers (Chairman, Dr. Eichelberger). The following resolution was unanimously adopted: "The American Astronomical Society assembled in Ann Arbor for its twenty-third meeting herewith expresses its appreciation of the kind hospitality extended to it by Director W. J. Hussey and Mrs. Hussey; also to Dr. Curtiss and the other members of the staff whose hearty co-operation added materially to the success of the meeting".

A hearty vote of thanks was tendered to Miss Annie J. Cannon for the careful performance of the arduous duties of treasurer of the Society. Miss Cannon was the second to hold this office in the Society, carrying its responsibilities since 1912.

Some amendments to the constitution were passed. One of these fixed more definitely the lengths of the terms of office. Another provided for the appointment by the president of a nominating committee, consisting of three members of the society, to prepare an official ballot. Considerable objection was raised before this amendment carried, for, while members have the privilege of substituting names for those on the ballot, nevertheless it was felt that those whose names appear on the ballot will invariably be elected and that the members will no longer have the choice of their officers but only the ratification of the selection made by the nominating committee, a distinct departure from democratic principles, and perhaps on that account to be regretted. However, the method worked out very satisfactorily in that the following officers were elected: *President*, 1919-22, Frank Schlesinger; *Vice-President*, 1919-20, George C. Comstock; *Vice-President*, 1919-21, Walter S.

Adams; *Treasurer*, 1919-20, Benjamin Boss; *Councillors*, 1919-21, S. I. Bailey and W. J. Hussey; *Councillors*, 1919-22, H. N. Russell, and V. M. Slipher. The Council for the coming year is composed of these officers and the following whose terms are unexpired: *Secretary*, 1918-21, Joel Stebbins; *Councillors*, 1918-20, E. W. Brown and Otto Klotz. The nominating committee were, Messrs. Brown, Eichelberger and Miller.

The attendance at the meetings was good from far as well as near points, there being over sixty members present. Thirteen new members were elected, among them being Dr. Shinzo Shinjo of the observatory of the Imperial University, Kyoto, Japan, who was on a tour of inspection of American observatories, and John Paraskevopoulos, from Greece, who is now at the Yerkes Observatory.

The fifty-six papers submitted, covering the usual wide range of subjects, may be grouped as follows, and mentioned only briefly under these headings: thirteen on sun and satellites; twenty on binaries, orbits and variables; six on star positions and motions; three on instruments and mechanical devices; and fourteen on miscellaneous topics.

Sun and Satellites: George Peters, "Methods of Asteroid Observation and Reduction". E. D. Roe, Jr., "Direct Micrometrical Observations of the Sun. Heliographic Positions of Sun-Spots". Method of observation and formulae were given. J. A. Miller, "Evidences of Change in Coronal Structure During the Eclipse of June 8, 1918". Some of the coronal arches over disturbed areas (referred to last year) appear to have not been continuous twenty-five minutes earlier, according to the observations on the plates taken by the Lick Observatory Expedition. W. D. MacMillan, "Origin of the Sun's Heat". An interesting philosophical discourse in which the great age of the universe was dwelt upon, but which scarcely approached the subject of the sun's heat when from the chairman came the relentless "Time's up". Edison Pettit, "The Eruptive Prominences of May 29, and July 15, 1919", and "Studies in Prominence Characteristics". A remarkable series of slides and pictures showed the gradual ascent of the parts of the prominence of May 29. The speed was calculated and shown on a chart. Uniform velocity was held for a time then the velocity increased and remained

uniform for another interval when it again increased and continued uniform as long as observed. Mr. Pettit has found this to be a characteristic of the velocity of ascent of prominences, a very important development in solar investigation. Through his courtesy and the kind permission of Professor Frost, two plates from the published paper (*Astrophysical Journal*, October) are reproduced here. (Plates VI, VII). E. S. King, "Colour Index of Planets". An application of the method presented at last year's meetings. W. F. Rigge, "The Annular Eclipse of the Sun of 1919, November 22, as Visible in the United States". L. A. Bauer, "Geophysical Observations during the Total Solar Eclipse of May 29, 1919". Successful atmospheric and magnetic observations were made at Cape Palmas in Liberia; and a picture of the eclipse taken with a small camera showed good detail when enlarged. R. E. De Lury, "Fluctuations in the Moon's Longitude in Relation to Meteorological Variations"; "Apparent Relation between Chinese Earthquakes and California Tree Growths, 0 to 1680 A.D."; "Levels of the Great Lakes in Relation to Numbers of Sun-Spots"; and, with John L. O'Connor, "Simultaneous Spectroscopic Observations of the Rate of Rotation in North and South Solar Hemispheres".

Binaries, Orbits, and Variables. Georges Van Biesbroeck, "The Use of Semi-Absolute Photographic Positions in Double Star Astronomy". Joel Stebbins, "Progress in Photo-Electric Photometry". Measures of minute variations in α Herculis and λ Tauri. Leon Campbell, "Some Recent Developments in the Study of SS Cygni". Annie J. Cannon, "The Spectra of Variable Stars of Long Period". J. A. Miller and J. H. Pitman, "The Masses of Thirty-two Visual Binary Stars". R. S. Dugan, "On the Eclipsing Variables, *RT* Persei and *U* Cephei". S. Albrecht, "Variations of Type in the Cepheid Variables *l* Carinae and Eta Aquilæ as shown by the General Spectrum". C. P. Olivier, "Measures of Double Stars on Photographs". J. S. Plaskett, "The Spectroscopic Orbits of the Eclipsing Variables *U* Ophiuchi, *RS* Vulpeculæ and *TW* Draconis"; and "Report on Progress of Work of 72-inch Telescope". W. E. Harper, "The Orbit of the Spectroscopic Binary, Boss 4507", "The Orbit of the Spectroscopic Binary Iota Delphini", and "Note on the Spectrum of Nova Aquilæ". R. K. Young, "The Orbit of the Spectroscopic Binary, Boss, 8427", "The Orbit of the Spectro-

scopic Binary, One Geminorum" and "The Orbit of the Spectroscopic Binary, Boss 4669". S. L. Boothroyd, "The Orbit of the Spectroscopic Binary, Boss 4602". E. E. Barnard, "Variable Stars in the Cluster M. 11" and "On the Change in the Period of the Variable Star, Bailey No. 33 in the Cluster M. 5". Solon I. Bailey, "A Systematic Search for Novæ at the Harvard College Observatory".

Star Positions and Motions. H. C. Lord, "Star Tables Good to the Year 2000 for Civil Engineers and Navigators". Hannah Steele Pettit, "The Proper Motions and Parallaxes of 359 Stars in *h* Persei". Anne S. Young and Louise F. Jenkins, "Preliminary Report upon an Attempt to Determine Proper Motions of Certain Long Period Variable Stars from Photographic Plates made with the 24-inch Reflector of the Yerkes Observatory". R. Trümpler and F. Schlesinger, "Experiments with Kapteyn's Method for Reducing Guiding Error". The advantages and disadvantages of the method of photographing the stars through out-of-focus, or disc, images of the stars were discussed. The earlier method of reducing the stronger images is still favoured. E. E. Barnard, "Remeasurement of Hall's Small Stars in the Pleiades". About one-fifth of the stars appear to belong to the cluster. R. H. Tucker, "Meridian Circle Observations of Nova Aquilæ".

Instruments and Mechanical Devices. A. E. Douglass, "Applications of the Periodograph to Variable Star Periods and Other Problems". Slides showed several successful applications of his optical periodograph. J. C. Hammond and C. D. Watts, "Rates of the Standard Sidereal Clocks at the Naval Observatory". G. E. Hale, "Preliminary Results of a Comparative Test of the 60-inch and 100-inch Telescopes". Some excellent slides from photographs of the same objects made by the two great telescopes of the Mount Wilson Observatory were shown, the results with the larger being superior. The ring nebula in Lyra, the spiral structure of a planetary nebula, a part of the moon showed marvellously well on the great scale of the projection. Through the kindness of Professor Hale the portion of a photograph of the moon is reproduced here (Plate VIII), and two views of the 100-inch telescope, borrowed from the *Publications of the Astronomical Society of the Pacific* are shown in Plates IX and X.

Miscellaneous Topics. George C. Comstock, "Preliminary Account of Some Investigations Upon the Atmospheric Refraction". Elliott Smith, "All-American Time". The proposal of having one time all over America was discussed, and advantages and disadvantages pointed out. R. H. Curtiss, "Studies of Class B Spectra Having Hydrogen Emission Lines". C. C. Kiess, W. F. Meggers, and F. M. Walter, Jr., "False Spectra Produced by Gratings". C. C. Kiess and W. F. Meggers, "The Red and Infra-Red Arc Spectra of Eight Chemical Elements". C. O. Lampland, "Photographic Observations of the Orion Nebula". H. A. Howe, "A Desideratum in Solving Kepler's Problem". Florence J. Stocker, "Tests of Dyes for Red and Infra-Red Photography". Tests of dyes made at the Bureau of Chemistry were made showing in general superiority over the older samples of foreign manufacture. A new dye, Kryptocyanin, with maximum at 7700 was also reported on. S. M. Burka, "Hypersensitising Panchromatic Plates". A solution containing 3 parts of strong ammonia solution to 75 parts of water and 25 parts of ethyl alcohol increases the sensitivity of certain panchromatic plates from two to four times. V. M. Slipher, "Spectrum of the Milky Way". The solar type is very noticeable, and the auroral line A is present always. Exposure required is about 20 hours. C. D. Perrine, "Spectrum of γ Argus". R. M. Stewart, "Peirce's Criterion", and "Treatment of Discordant Observations". E. E. Barnard, "On the Varnishing of Astronomical Negatives".

The papers and discussions were very interesting. Perhaps the discussions and conversations are the most valuable features of the meetings, revealing as they do interesting and valuable details so often missing in the formal presentation of the papers. The success of the meetings was in great part due to the efforts of Professors Hussey, Curtiss and Hopkins who, co-operating with the Council, insured in the arrangements every comfort for those attending the meetings. The visitors were made to feel very much at home in the 'homey' college town. Thanks are due to the young ladies who volunteered to serve the excellent repasts prepared for members in the Michigan Union.

DOMINION OBSERVATORY,
Ottawa, October, 1919.

ON THE EXISTENCE OF EXTERNAL GALAXIES[1]

By Harlow Shapley

I. Introduction

In the present state of astrophysical knowledge, the problem of the existence of external stellar systems similar to our Galaxy reduces almost immediately to the problem of the status of spiral nebulae in the sidereal universe. In treating this question we must deal primarily with the "island-universe" hypothesis of spirals—an interpretation of long standing, which at the present time has many adherents and appears to be growing in general acceptance.[2]

The recent work on star clusters, in so far as it throws some light on the probable extent and structure of the galactic system, justifies a brief reconsideration of the question of external galaxies, and apparently leads to the rejection of the hypothesis that sprial nebulae should be interpreted as separate stellar systems. During the last two or three years a considerable amount of observational material bearing on the problem has come to hand, much of which was either not known or not fully considered by previous writers on the subject.

Four classes of objects, other than spiral and closely associated nebulae, have at times been suggested as possible external galaxies, the first three of which may be dismissed as no longer open to such

[1]From the *Publications* of the Astronomical Society of the Pacific for October 1919.

[2]Among special discussions of the theory, three should be mentioned: an article by Puiseux, "Spiral Nebulae," *Revue Scientifique*, April 6, 1912; Crommelin's paper "Are the Spiral Nebulae External Galaxies?" *Scientia*, v. 21, p. 365, 1917 (reprinted in the *Journal of the Royal Astronomical Society of Canada*, v. 12, 33, 1918); and the recent address by Curtis, "Modern Theories of Spiral Nebulae," *Journal of the Washington Academy of Sciences*, v. 9, 217, 1919. In all of these the evidence is held to be favourable to the "island universe" theory. The arguments reviewed and extended by Curtis are so fully and clearly expressed that they may be taken as presenting the case for the stellar interpretation of spiral nebulae. The alternative theory that the spirals are not stellar has been maintained little, if at all, in recent years.

interpretation: (1) *Large star clouds of the Milky Way:* the affiliation with the galactic region and its characteristic population shows them to be a fundamental part of the galactic system; (2) *The Magellanic Clouds:* the apparent magnitudes of their short-period variable stars determine definitely the order of the distance and size of these detached stellar systems, and prove them to be small in comparison with the galactic system;[1] (3) *Globular clusters:* those so far discovered are recognized now as dependents of the galactic system, although in many respects they are miniatures of the Galaxy and apparently for the most part are external to the regions where most of the galactic stars are found; (4) *Various peculiar nebulae and nebulous stars:* concerning them little is known, but in most cases they are to be classed with the ordinary gaseous nebulae (which are clearly associated with the Milky Way), or with peculiar types of individual stars, or with the faint spirals.

II. Outline of Evidence Bearing on the "Island Universe" Hypothesis.

The relation of the spirals to the galactic system is not so easily disposed of as the cases considered above. In support or in partial support of the hypothesis that spirals are external stellar systems arguments based on the following four points may be advanced:

(*a*) Distribution with respect to the galactic plane, assuming obstruction of light in and near the Milky Way.[2]

(*b*) High radial velocities.

(*c*) Certain spectral characteristics.

(*d*) Some evidences of great distance.

Less definite propositions that may be ranged on this side of the question are:

(*e*) Improbability of a single galactic system in the sidereal universe.

(*f*) Physical appearance of a few of the spirals.

(*g*) Resemblance of structure in spirals to hypothetical spiral structure of the Milky Way System.

In the light of recent studies of nebulae and the galactic system the arguments founded on the seven foregoing points do not appear

[1] *Mt. Wilson Contr.*, No. 151, pp. 20 and 25, 1917; No. 152, p. 2, 1917.

[2] *Cf.* Curtis, *loc. cit.*, *p.* 225.

to establish the stellar interpretation; and none of them appears to be particularly troublesome for the hypothesis that the spiral nebulae are not external stellar systems. Many of these arguments in fact, are better interpreted according to this alternative theory that spiral nebulae are truly nebular objects.

Five additional points, which are apparently of much weight, and, taken together, seem decidedly unfavourable to the stellar interpretation of spirals, are as follows:

(*h*) New conception of the dimensions of the galactic system.

(*i*) Measures of internal motion in spiral nebulae.

(*j*) The occurrence of novae in spirals and their magnitudes at maximum.

(*k*) The systematic nature of the radial motions of spirals.

(*l*) The probable dependence of their distribution on galactic position.

Some of the foregoing are not completely independent of each other.[1] Four further points of less weight that may be suggested as opposed to the "island universe" theory are:

(*m*) The possibility of formulating a fairly satisfactory nebular theory of the spirals.

(*n*) Directly measured parallaxes.[2]

(*o*) The data of proper motion relative to mean distances and drifts.

(*p*) The apparent absence of a central nucleus in the galactic system.

III. Remarks on the Principal Points Favouring the "Island Universe" Hypothesis.

a and *l*. The well-known avoidance of low galactic latitude by spiral nebulae, and the progressive but irregular concentration to the galactic poles, is most naturally taken as evidence that the distribution of spirals and galactic stars is to a certain extent complementary; therefore, that the spirals are dependent and subordinate factors of the general system. It would be difficult indeed to believe that external and independent stellar "universes" could exhibit such

[1]For instance, the value of *j* may involve a partial acceptance of *h*.

[2]van Maanen, *Mt. Wilson Contr.*, No. 158, 1918.

striking relations to our particular stellar system when, in addition to this apparent dependence of distribution on galactic latitude, we also note: first, that the avoidance by spirals (particularly by the brighter ones) is greatest in the direction of the galactic centre where the stars, globular clusters, planetary nebulae, etc., are most numerous, and that the avoidance is least in the northern hemisphere where the Milky Way is the thinnest and globular clusters are totally absent; and, second, that the radial velocities observed are not random, but have a definite relation to the galactic system and perhaps even depend on the angular distance from an apical point in or near the Milky Way.[1]

On the other hand, Campbell,[2] Curtis,[3] and others have proposed that spirals may actually be distributed at random, and that the apparent distribution with respect to the Galaxy can be explaned by assuming that obstructing matter encircles the galactic discoid —dark occulting nebulosity analogous to that observed in the peripheral equatorial regions of many spiral nebulae. Patches of dark nebulosity certainly exist in the galactic system, at no great distance from the Sun, and it is quite possible that the apparent avoidance of the lowest latitudes by globular clusters is due to such material.[4] Spirals in the galactic plane beyond the confines of our system would be occulted as readily as globular clusters. In general, the observed distribution could be secured by liberal use of the hypothetical encircling opaque material.

The region avoided by spirals, however, particularly in the southern hemisphere, is many times wider than that avoided by globular clusters. A great area of the southern sky (well out of the Milky Way[5]) is quite transparent both to near and to extremely distant globular clusters, but it is practically devoid of spiranebulae sufficiently bright to have been observed. We must conclude, it appears, either that the spirals, whether near or distant, do not exist in that direction, or that there is a most remarkable

[1] *Mt. Wilson Contr.*, No. 161, Section VII, 1918. *Cf.* also reference below to work by Wirtz.

[2] *Science, N.S.*, **45**, 531, 1917.

[3] *Loc. cit.*

[4] Shapley, *Proceedings of the National Academy of Sciences*, **5**, 344, 1919.

[5] Between galactic latitudes $+5°$ and $+25°$, $-5°$ and $-25°$.

arrangement of obscuring patches that eliminates all spirals but leaves a normal distribution of globular clusters.[1]

b. A few years ago Slipher's discovery that spiral nebulae as a class have extraordinary high radial velocities gave new life to the theory that these objects are distant stellar systems.[2] The average motion of the various types of stars and nebulae has been contrasted many times and the argument advanced that, since all galactic objects have reasonably small velocities, these peculiarly high values should therefore be attributed to separate "universes" During the last few years, however, this supposed isolation of the spirals has been altered. While their average radial velocity exceeds 500 km/sec, it is less than 400 km/sec for one-third of them. A number of galactic stars are now known with space velocities equal to or in excess of 400 km/sec. With the extension of the investigations of proper motion and radial velocity to the fainter magnitudes many high stellar velocities are being found.[3] Many globular clusters,[4] which are certainly subordinate to the galactic system, have radial velocities between 100 and 300 km/sec, and the great Magellanic clouds[5] also appear to have very high velocities of recession. Hence this argument of peculiarity in velocity seems no longer an important one for the "island universe" theory. High speed is not a condition impossible of production by the forces inherent in our galactic system.

c. The integrated and nuclear spectra of spirals are predominantly of a stellar type—usually resembling class G or K. With small dispersion the composite spectrum of a mixed group of stars,

[1] A third explanation that spirals, as compared with globular clusters, are very near to the solar system cannot be accepted in the face of other evidences of distance.

[2] That the large line-displacements in the spectra of spiral nebulae should be attributed to motion in the line of sight appears to be assured by a consideration of the following points: (1) The displacements are both positive and negative; (2) The appropriate relation of shift to wave-length is observed; (3) Orbital motions in eclipsing binaries occasionally show displacements of the same order of magnitude; (4) In linear velocity the rotation observed spectroscopically in some spirals approaches the velocity in the line of sight.

[3] Adams and Joy, *Mt. Wilson Contr.*, No. 163, 1919; *cf.* Wolf's frequent notes on large proper motions in recent volumes on the *Astronomische Nachrichten.*

[4] *Mt. Wilson Contr.*, No. 156, p. 12, 1918.

[5] R. E. Wilson, *Proc. Nat. Acad. Sci.*, **1**, 183, 1915.

such as a globular cluster or a galactic system, would appear much the same. On the other hand bright lines are also found occasionally, and Seares's preliminary work on the distribution of colour would indicate a much bluer spectral type for the nebular condensations in a spiral than for the nucleus.[1]

The analogy of the absorption spectrum of spirals with the composite spectrum of a stellar system cannot be carried very far, however, until higher dispersion has been used. We should remember that for many years stars differing so enormously in density, volume, and mass as the giant and dwarf eclipsing binaries of type G were classed together without question. Sidereal bodies in extremely different physical states obviously may give closely comparable spectra on the small dispersion that has been used for spiral nebulae.

d and *f*. With one or two possible exceptions the secondary nuclei in spiral nebulae are so distinctly nebulous that they cannot be considered individual stars. Even in Messier 33, probably the most conspicuously nucleated of the brighter spirals, it is easy on large-scale plates to distinguish between the superposed stellar images and the "softer" nebular condensations. It is possible, however, to see a resemblance of these diffuse nebulous objects to extremely distant stellar clusters,[2] but unless we introduce further unverified assumptions the analogy breaks down when the observed colours are intercompared.

IV. Evidence Unfavourable to the "Island Universe" Hypothesis.

The observational and theoretical evidence against the stellar interpretation of spiral nebulae has already been discussed in various earlier papers on clusters;[3] in the present article space will be taken for only a brief summary of the arguments.

h. Formerly we compared any hypothetical external galaxy with a stellar system supposedly about 10,000 or 20,000 light-

[1] *Mt. Wilson Communication*, No. 36, 1916.

[2] *Publications Astr. Soc. Pac.*, **29**, 217, 1917.

[3] *Ibid.*, **30**, 42, 198; *Mt. Wilson Contr.*, No. 157, p. 1, 1918, and No. 161, Sections VII and VIII, 1918.

years in diameter. Recent studies of the galactic system indicate that its greatest diameter is not less than 300,000 light-years. This newer conception greatly embarrasses the interpretation of spirals as stellar organizations of a size comparable to that of the Galaxy. To be linearly as great as this, though angularly small, demands a distance from the Earth, even for the spirals of largest angular size, that would completely discredit many observational results. For example, if any bright spiral of 10′ greatest apparent diameter has an actual diameter directly comparable with that of the galactic system, its distance must be greater than a hundred million light-years.

i. Under such circumstances the measures of internal motion by van Maanen, Kostinsky, and Lampland, would need to be summarily rejected. For instance, van Maanen's[1] careful measures of the nebulous points in Messier 101 would indicate rotational velocities greater than the velocity of light if that spiral is held to be even one-fifth as large as our Galaxy now appears to be. Similarly, the systematic drift derived by Wirtz[2] from a study of several hundred spirals, and the average proper motions suggested by the studies of Wirtz and Curtis[3] would indicate appalling velocities in space—quite irreconcilable with the spectroscopically measured velocities of translation and rotation.

j. Moreover, if in real dimensions spiral nebulae were analogous to our galactic system, the absolute magnitude of the novae in spirals would far transcend any luminosity with which we are acquainted, and would be at direct variance with present results on intrinsic stellar brightness. For at the distance computed above the absolute magnitude of a nova of the sixteenth apparent magnitude would be -16, nearly two hundred thousand times as bright as the novae of the galactic system for which van Maanen has determined the absolute luminosities.[4] An upper limit to the

[1] *Mt. Wilson Contr.*, No. 118, 1916.

[2] *Astronomische Nachrichten*, **203**, 197, 293, 1916; **204**, 23, 1917; **206**, 109, 1918.

[3] *Pub. Ast. Soc. Pac*, **27** 217, 1915. In subsequent references Curtis has stated his lack of confidence in the reality of the observed proper motion. *Jour. Wash. Acad. Sci.*, **9**, 221, 1919. The average time interval between first and second observations is 13 years and 40 years respectively, in the investigations by Curtis and by Wirtz.

[4] *Cf. Pub. Ast. Soc. Pac.*, **31**, 234, 1919.

intrinsic brightness attainable by stars is suggested by recent observational and theoretical work, and this limit is much fainter than −16. The study of globular clusters, for example, has yielded sufficient knowledge of the luminosity of more than a million stars to show that not one is within ten magnitudes of this enormous brightness. The luminosity of about 2000 stars of the solar environs is now known, and probably none is even a ten-thousandth as luminous as absolute magnitude −16. Hence stellar luminosities of this order seem out of the question, and accordingly the close comparability of spirals containing such novae to our Galaxy appears inadmissible.

Let us abandon the comparison with the Galaxy and assume an average distance for the brighter spirals[1] that will give a reasonable maximum absolute magnitude for the novae. Then the measured internal motions also become reasonable and in good agreement with spectroscopically determined rotational velocities; likewise the distances become reconcilable with the data from proper motion.

The simple hypothesis[2] that the novae in spirals represent the running down of ordinary galactic stars by the rapidly moving nebulosity becomes a possibility on this basis of distance, for the brighter spirals are within the edges of the galactic system. Further, it is possible to explain the peculiar distribution of spirals and their systematic recession by supposing them repelled in some manner from the galactic system, which appears to move as a whole through a nebular field of indefinite extent.[3] But the possibility of these hypotheses is of course not proposed as competent evidence against the "island universe" theory.

[1]Provisionally, let us say, of the order of 20,000 light-years. If novae in spirals attain apparent magnitude 16, certainly bright stars, if present, should be easily photographed, and the failure o resolve he brightest spirals indicates that they are not composed of typical stars. (*Cf.* a suggestion on the origin and constitution of spiral nebulae, *Mt. Wilson Contr.*, No. 161, p. 29, and also the mathematical theory by Jeans, *Monthly Notices*, **77**, 186, 1917). At a distance of 20,000 light-years, if there were ordinary stars of absolute magnitudes between 0 and +5, they would appear of magnitudes 14 to 19, and therefore conspicuous on ordinary photographs. Even if 200,000 light-years distant, the giant stars would be easily resolved on existing photographs.

[2]*Pub. Ast. Soc. Pac.*, **30**, 53, 1919.

[3]*Mt. Wilson Contr.*, No. 161, Sections VII and VIII, 1918.

V. Conclusions.

Observation and discussion of the radial velocities, internal motions, and distribution of spiral nebulae, of the real and apparent brightness of novae, of the maximum luminosity of galactic and cluster stars, and finally of the dimensions of our own galactic system, all seem definitely to oppose the "island universe" hypothesis of the spiral nebulae. Data relating to proper motion are also in better harmony with the hypothesis that spiral nebulae are not stellar systems. The evidence now supporting the "island universe" interpretation appears unconvincing, for many of the best arguments formerly proposed on that side of the question have been invalidated or much weakened by recent research. We have, however, no evidence that somewhere in space there are not other galaxies; we can only conclude that the most distant sidereal organizations now recognized—globular clusters, Magellanic clouds, spiral nebulae—cannot successfully maintain their claims to galactic structure and dimensions.

OUTLINE OF CONSTRUCTION WORK OVER CANADA OF THE GEODETIC SURVEY OF CANADA FOR THE YEAR 1919

By Noel Ogilvie, *Superintendent*

THE conclusion of the great war undoubtedly emphasized the importance of the engineer's work and the need of having his work done before emergencies arise.

The war would never have been won if accurate topographic maps had not been procurable; maps not only useful for military purposes, but for all engineering feats along the lines of irrigation, railway construction, canal construction, etc.

As it is well recognized that such maps can only be authentic and reliable if based on a geodetic survey, it naturally follows that the demands on the Geodetic Survey of Canada made by other surveys and corporations are heavy and are increasing from year to year.

During this year in particular the Geodetic Survey of Canada was called upon to give its basic aid to a special mapping survey that was being made of the Fraser river and the city of Vancouver. The Fraser river, as is well known, has always been full of vagaries in its meandering, but its channels will finally be controlled and dyked, thus making it navigable to ocean going vessels. The Geodetic Survey of Canada has made a beginning in this work by running 180 miles of precise levels and by establishing a number of geographic points to be used by the Department of the Naval Service as control for soundings, and by the Geological Survey in making the detail map of the country. Thus an engineering work of national importance is progressing which is founded on results of the Geodetic Survey of Canada.

But in speaking of activities in the West we must not forget to mention the aid undertaken in the East. The Geodetic Survey of Canada, still young in its activities, has not hesitated to exert its strength in helping the Department of the Naval Service in its survey of the Lower St. Lawrence by erecting a number of triangu-

lation stations below Quebec. These stations are from 15 to 45 miles apart, and are used as a basis by the Hydrographic Survey to control the scale and geographic positions of their charts of the river.

The strong constructive work of the Geodetic Survey of Canada along the bay of Fundy has been extended to Halifax and is thus in a position to afford co-operative relief to the military and naval surveys which are in operation in the interior and along the coast of Nova Scotia. It will also provide excellent control for all the completed or contemplated surveys of the city of Halifax and surrounding towns, for it must be remembered that without such relief all maps of other surveys would most probably clash when meeting maps founded on datums other than the North American Datum. The relief offered by the Geodetic Survey of Canada is always enhanced in value by the fact that the North American Datum has been adopted. As an avoider of map clashing the aid of the Geodetic Survey of Canada will always be welcomed by other surveys and engineers.

It would not be well to forget to say here that the Geodetic Survey of Canada not only has operated over large extents of territory this summer, but has been called upon to give aid to those parts of Canada where the population is densest, thus assisting in city triangulation work. Particular mention is to be made here of the aid given this year to the City Engineer of Montreal in his desire to obtain a control basis for detail mapping of Montreal. Too great care could not be exercised and the city of Montreal was fortunate in having the primary points of the Geodetic Survey of Canada so close and so available, thus founding a scheme and basis for Montreal's mapping that should last for all time.

THE NATURE OF A SUSPECTED VARIATION OF THE SOLAR ROTATION IN 1915.

By RALPH E. DE LURY.

Articles on this topic have been published in the *Astrophysical Journal*, and now since a fifth article has appeared in the last number of this JOURNAL, (pp. 391-402), I make reply, very briefly however, for I feel that this subject has already filled more journalistic space than the observational material warrants.

With reference to pp. 391-2: I pointed out the fallacy of using the measurements of the solar rotation in question with my observations of brightness and haziness made some hours later and ignoring the observations of brightness and haziness made at the same time as the rotation observations. By associating the references to brightness and haziness with the observations of solar rotation to which they pertain, I found

	km. per sec.
'19 plates, B, "5" and "4-5", mean velocity	1.975
50 plates, B, "4", *i.e.*, "normal", mean velocity	1.958
42 plates, B, "3-4" and "3", mean velocity	1.942';

and,

'in accordance with the haze explanation that low values of the measurements of solar rotation are associated with haze and higher values with "no haze", thus:

		km. per sec.
June	21, "B, 3-4, A little haze near sun"	1.846
July	4, "B, 3-4, Haze"	1.893
July	20, "B, 4, No haze"	2.026
July	23, "B, 4-5, Positively no haze"	2.003
August	16, "B, 4, Practically little or no haze"	1.977';

also,

		km. per sec.
'June	21, 6:45– 8:00 a.m., B, 4	1.911
June	21, 10:18–10:38 a.m., Bright	2.007
July	11, 7:00– 7:19 a.m., B, 4, then hazed up	1.975
July	11, 9:26–10:58 a.m., very hazy, cirrus clouds	1.785
July	11, 11:37–11:49 a.m., brighter, still hazy	1.805';

and, that measurements of both series of plates

> "satisfy the criterion of blended spectrum of haze in agreement with the record of observational conditions";

and,

> "the *known* terrestrial sources of blended spectrum offer a reasonable explanation of the supposed variation in rotation, so that it is unnecessary to employ the *hypothetical* element of my explanation, which supposes an interplanetary or solar source of blended spectrum".

On line 10, p. 395, after, "changes applied to four days only would make $r=+0.02$", might have been added the following: On the other hand, similar changes in the opposite sense made on four days would make $r=+0.5$. The "correlation ratio" might preferably have been computed since one of the characters was unmeasured and "based on a variable mental standard".

The two meanings of "per cent haze" have been confused (pp. 391-401). The ratio of the times required to produce equal photographic densities due to continuous spectrum from limb and from haze, is not equal to the ratio of the intensities of the continuous spectrum from these two sources, (see this JOURNAL, **10**, 202, 1916, and **11**, 23, 1917). Conclusions drawn on this assumption are invalid.

The computations of the blending of spectrum lines (pp. 398-400) are made on the assumption that the ratio of the intensities of the lines is the same as that of the continuous spectra of limb and haze; and also that the only difference in wave-length between the two blended lines is due to rotation. The conclusions drawn are therefore in error, the values of the reductions in velocity being in general too small.

When the publication (mentioned p. 402, l. 1) on solar radiation arrived here in July 1918, I plotted the values of the "solar constant" along with the values of rotation in question (1915). Any measure of agreement they exhibit may be viewed in the light of my suggestion that haze would affect solar rotation and radiation at the same time (see this JOURNAL, **10**, 350, 1916, and **12**, 437, 1918), but as I pointed out, "It is important that both observations be made precisely simultaneously at the same place".

Certain unpublished results are referred to (p. 396): I am looking forward with great pleasure to contribu-

tions from other observatories which will aid in finally separating terrestrial from interplanetary and solar causes of such variations. The task is not a simple one. Some measure of success may be derived by observations made at times of solar eclipse (as I have pointed out in the *Astrophysical Journal*, **47**, 199, 1918). Finally, I see no reason as yet for withdrawing any statement or conclusion appearing in my previous notes (*Ibid.* **44**, 198 and **48**, 195) concerning the nature of the supposed variation in the solar rotation in 1915.

DOMINION OBSERVATORY,
Ottawa, December, 1919.

THE ORBIT OF THE SPECTROSCOPIC BINARY ι DELPHINI

By W. E. Harper

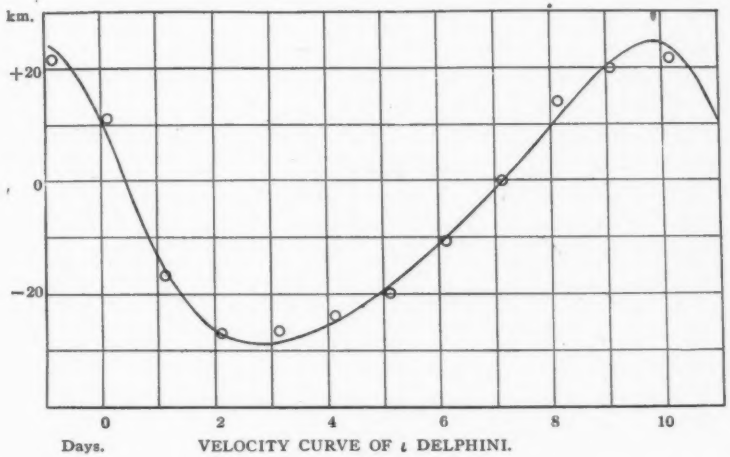
This star (1900 $\alpha = 20h\ 33.0m$, $\delta = +11°\ 02'$, photographic magnitude 5.49, type A2) was announced as a spectroscopic binary by Adams in the *Astrophysical Journal*, Volume XXXV, page 178, from three plates made in 1911. The revised measures of these, kindly communicated by Professor Hale, are as given in the table of observations. They have served in determining the period very closely, as 262 revolutions have occurred between the first Mount Wilson plate and the last one made here. Apart from this they have not been used in the determination, but they agree well with our curve, the residuals all being under 2 km. Six spectrograms were secured also by the writer while at the Dominion Observatory, Ottawa, and they have served to decide between two possible periods as adduced from connecting up the Mount Wilson observations with those made here at Victoria. The period finally accepted is 10.9960 days and the phases listed in the accompanying table are based on this value using the final value of periastron passage. All plates are given equal weight.

The spectrum is quite similar to that of Boss 4507 and Boss 4669, both recently investigated here, and has a multitude of metallic lines showing in addition to the intense and well-defined hydrogen lines and calcium *K* and the less strongly marked magnesium λ4481. From 12 to 20 lines were measured on each plate and the error of a single plate should consequently be small, but for some reason or other it is considerably larger than might be expected. In the case of Boss 4669 the probable error of a plate was ±1.0 km. per sec.; in Boss 4507 the error was ±1.2 km per sec., while in this star it is nearly ±1.9 km per sec. An examination of the plates reveals nothing in the nature of complexity of the lines, though if two spectra were present the range is entirely too small for them to be resolved unless the masses were very disproportionate.

The period being so close to the even eleven days there are only that many points on the curve when the observations were grouped. Preliminary elements were obtained in the usual graphical way and a least squares solution put through.

OBSERVATIONS OF ι DELPHINI.

Plate	Date	Julian Date G.M.T.	Phase	Velocity	Lines	Residuals O–C
Mt. Wilson	1911—					
" "	Sept. 9	2,419,289.744	8.904	+19.6		+0.2
" "	" 18	298.754	6.918	− 3.4		−1.0
" "	Nov. 2	2,419,343.631	7.811	+ 9.3		+2.0
	1919—					
2027	May 20	2,422,099.953	4.137	−24.7	14	+0.0
2044	" 28	107.953	1.141	−20.5	11	−4.5
2054	" 30	109.941	3.129	−26.6	19	+2.0
2076	June 2	112.949	6.137	− 6.9	18	+2.8
2089	" 3	113.964	7.152	− 0.2	14	−0.2
2099	" 4	114.930	8.118	+12.1	15	+1.3
2114	" 6	116.955	10.143	+21.5	14	−2.0
2121	" 9	119.916	2.109	−27.2	12	+0.0
2130	" 11	121.933	4.126	−23.1	15	+1.6
2140	" 16	126.916	9.108	+18.8	14	−2.2
2150	" 17	127.941	10.133	+21.8	14	−1.8
2157	" 18	128.937	.133	+10.3	17	+2.3
2170	" 23	133.911	5.107	−15.9	16	+2.6
2189	" 26	136.937	8.133	+15.8	14	+4.9
2229	" 30	140.933	1.133	−12.9	18	+2.8
2477	July 21	161.883	.091	+12.2	13	+3.2
2568	" 28	168.961	7.169	+ 0.1	11	−0.2
2583	" 30	170.830	9.039	+21.0	16	+0.5
2601	Aug. 6	177.829	5.041	−24.1	13	+5.1
2618	" 7	2,422,178.895	6.107	−14.5	14	+4.4



VELOCITY CURVE OF ι DELPHINI.

ELEMENTS OF ι DELPHINI.

		Preliminary	*Final*
Period	P	10.9960 days	10.9960 days
Eccentricity	e	.20	.252±.025
Longitude of Periastron	ω	65°	60°.81±8°.19
Velocity of system	γ	−4.65 km.	−5.50 km.±.52 km.
Semi-amplitude of range	K	25 km.	26.72 km.±.73 km.
Periastron passage	T	J.D.2,422,096.013	J.D.2,422,095.816±.237
$a \sin i$			3,909.500 km.
$\frac{m_1^3 \sin^3 i}{(m+m_1)^2}$			.020. ⊙

The solution improved the agreement considerably though, as stated previously, the probable error of ±1.9 km. for a plate is much larger than was hoped for from the character of the spectral lines. The graph represents the final elements, the grouped velocities being plotted.

DOMINION OBSERVATORY,
VICTORIA, B.C.
August 11, 1919.

THE ORBIT OF THE SPECTROSCOPIC BINARY BOSS 4507

By W. E. Harper

This star (1900 $\alpha = 17^h\ 44.4^m$, $\delta = +47°\ 39'$, magnitude 6.34, type A0) was suspected to be a binary from the large velocity obtained from the first plate made. Though the second plate gave a velocity almost identical with that of the first, yet the third plate, differing by over 30 km from either of the first two, confirmed the binary character of the star. As the range was sufficiently large to warrant proceeding with the determination of its orbit, the star was followed quite regularly and the 23 plates, upon which this discussion is based, were obtained within seven weeks of the date of the first spectrogram. The star has been one of the easiest which it has been the writer's experience to investigate and satisfactory elements were obtained with a minimum amount of labor.

The hydrogen lines are much narrower in this spectrum than is generally the case for this type and they, with the magnesium λ4481 and calcium K λ3933, are the most intense and best measurable upon the plates. But there are in addition numerous metallic lines which while not so intense are nevertheless sufficiently definite

OBSERVATIONS OF BOSS 4507.

Plate Number	Date	Julian Date G.M.T.	Phase	Velocity	Lines	Residua
	1919—					
2043	May 28	2,422,107.927	1.214	−85.6	16	+0.6
2056	" 31	110.808	1.271	−86.4	20	−1.3
2120	June 9	119.891	1.881	−28.3	11	+1.2
2133	" 14	124.828	1.170	−89.4	13	−2.8
2139	" 16	126.894	.412	−20.8	16	−0.7
2152	" 18	128.805	2.323	+23.0	17	+0.5
2165	" 23	133.830	1.699	−53.8	16	−2.4
2186	" 26	136.838	1.883	−30.0	11	−1.9
2195	" 28	138.823	1.044	−86.3	14	−2.0
2206	" 29	139.830	2.051	− 8.5	12	−2.2
2216	" 30	140.715	.111	+17.0	12	+0.6
2223	" 30	140.847	.243	+ 4.5	14	+2.6
2232	July 1	141.749	1.145	−85.4	11	+1.1
2252	" 2	142.800	2.196	+12.7	11	+1.9
2263	" 3	143.765	.337	− 9.1	14	+1.1
2277	" 6	146.789	.537	−39.4	13	−2.2
2288	" 7	147.707	1.455	−72.7	17	+2.8
2297	" 7	147.864	1.612	−60.2	13	+1.0
2305	" 8	148.709	2.457	+31.3	13	+0.6
2312	" 8	148.826	2.574	+32.8	13	−0.9
2315	" 8	148.880	2.628	+33.8	14	+0.4
2325	" 9	149.793	.717	−56.6	19	+2.9
2362	" 14	2,422,154.071	2.800	+24.4	18	−2.9

for measurement and the agreement of the results for the different lines is very accordant. While the number of lines measured on each plate varied from 11 to 20 yet all the plates were felt to be dependable and they have been given equal weight in the solution. In the table on p. 455 the phases have been reckoned from periastron, using the final values of P and T. The residuals are computed for each plate.

Thanks to a good run of weather at the time, no trouble was experienced in getting the period, as the variations could be followed closely. The preliminary value obtained was 2.824 days. When the observations were reduced to one period and plotted it was seen that while they followed a sine curve approximately yet there was, without doubt, better agreement when a small eccentricity was used with the longitude of periastron in the first quadrant. Accordingly provisional elements were adopted as follows.

PRELIMINARY ELEMENTS.

Period	$P = 2.824$ days.
Eccentricity	$e = .02$
Longitude of periastron	$\omega = 30°$
Velocity of system	$\gamma = -27.24$ km.
Semi-amplitude of range	$K = 60$ km.
Periastron passage	$T =$ J.D. 2,422,106.732

As no previous observations existed it was felt desirable to carry through a term for the period in the least-squares solution. The following plates were grouped to form three normal places: 2043 and 2056, 2133 and 2232, 2312 and 2315. These are at minimum and maximum where they have little or no effect on the correction for the period in the solution. All other plates were used separately and thus there were 20 observation equations built up according to the Lehmann-Filhés notation. Owing to the very small value of the eccentricity it was decided to consider ω as fixed.

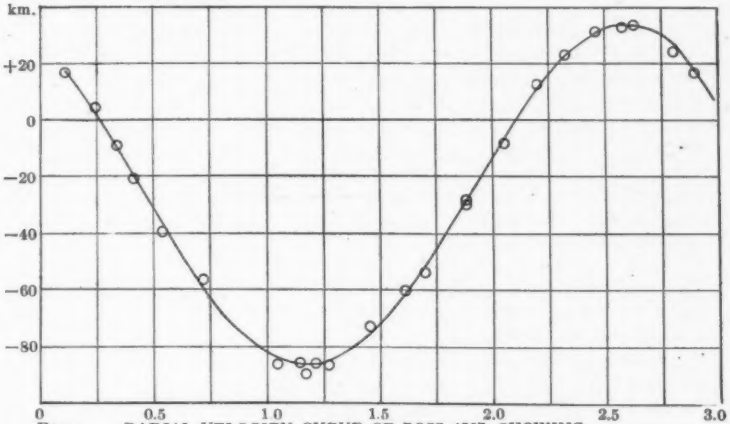
The solution gave very small corrections to the preliminary values as follows:

$$\delta\gamma = -.06 \text{ km.}$$
$$\delta K = +.15 \text{ km.}$$
$$\delta e = -.003$$
$$\delta P = +.00024 \text{ days}$$
$$\delta T = -.019 \text{ days.}$$

so that the final values, with their probable errors, are the following:

FINAL ELEMENTS.

$P = 2.82424$ days $\pm .00011$ days
$e = .017 \pm .007$
$\omega = 30°$
$\gamma = -27.30$ km $\pm .30$ km.
$K = 60.15$ km. $\pm .47$ km.
$T =$ J.D. $2{,}422{,}106.713 \pm .038$ days
$a \sin i = 2{,}335{,}700$ km.
$\frac{m_1^3 \sin^3 i}{(m+m_1)^2} = 0.06\ \odot$



RADIAL VELOCITY CURVE OF BOSS 4507, SHOWING INDIVIDUAL OBSERVATIONS.

The solution reduced the squares of the residuals about 25 per cent. and gave as the probable error of a plate the low value of ± 1.2 km. per sec. For single prism work with a dispersion of about 35 A. per millimetre and for a spectrum with lines of only moderate sharpness, this is extremely satisfactory and speaks well for the performance of the instrumental equipment. No doubt the long focal length of the telescope, 108 feet, and the consequent complete illumination of the slit, combined with good seeing conditions, all contribute to the accuracy of the measures.

The graph shown represents the final elements with the individual observations plotted. All the residuals are under 3 km.

DOMINION OBSERVATORY,
VICTORIA, B.C.
July, 1919

MEETINGS OF THE SOCIETY

At Toronto.

November 4.—The Society met at 8 p.m. in the Physics Building of the University of Toronto, the President, Mr. A. F. Miller, in the chair.

Weather conditions during the past two weeks having been unfavorable for observation, Mr. A. F. Miller had made only two observarions of Nova Aquilæ 3; which indicate slow, but certain, decline in the light of this interesting object, which has fallen to between the 7th and 8th magnitudes. It still appears to have a bright stellar nucleus with the same greenish-white margin already mentioned on several former occasions. No change in the spectrum has been noticed; the nebulium lines and Hβ, with a narrow continuous spectrum, can still be distinguished visually despite the faintness of the object.

He also reported that he had observed sunspots on several occasions within the past fortnight, particularly in the afternoon of Nov. 3, when no less than seven groups were readily seen with a small telescope. Two groups contained large spots, evidently in a condition of activity.

Mr. Miller showed a simplified arrangement for obtaining the spectra of metals and salts in solution. Generally, an induction coil giving not less than a 4-inch spark is found necessary for this purpose; however, he has been able to obtain the spectra of such metals as magnesium, zinc, copper, lead, mercury, thallium, calcium, and several others by means of a coil giving only a half-inch spark; and the readiness with which the smaller apparatus can be put in operation is often a great advantage when time cannot be spared to set up the more elaborate equipment required in connection with a large coil. His arrangement consists of a very small condenser, made by affixing two pieces of tin foil and having about 3 square inches surface on opposite sides of a 4 x 5 inch glass plate. The holders for the metal electrodes giving the spectrum are pieces of ordinary iron wire 3 inches in length, terminating in small pincettes of thin sheet iron. Each wire holder is passed through a hole bored transversely through a small cork, the corks being affixed to the glass plate by sealing-wax or other cement. Connection between opposite sides of the condenser and the respective metal-holders is effected by narrow strips of tin-foil. When the poles of the coil are attached to the sliding wire rods, and the distance between the electrodes suitably adjusted, a small brilliant arc is formed between these latter showing the principal bright lines of the metal when viewed through a spectroscope, either with the slit directed toward the arc, or by reflexion with a comparison prism. To permit adjustment of the electrodes while the coil is in operation, small handles are provided, made

by rolling varnished paper round the outer extremities of the sliding wires. To obtain spectra of metallic salts, small capillary tubes of paper filled with saturated solution of the salt and traversed internally by fine iron wires, are employed instead of the pincettes and metal electrodes. Since iron does not give line-spectrum with the small spark employed in these experiments, it serves perfectly as a substitute for the platinum metal-holders necessary with the intense spark of a powerful coil.

Prof. Chant showed a beautiful photograph of a portion of the moon which he had just received, and which had been made by the new 100-inch reflector at Mount Wilson.

Mr. Wm. Bruce of Hamilton gave the address of the evening on "An Astronomer's Search for Hell and Heaven". An incident of some interest was that this date was his 86th birthday anniversary. The paper consisted in an imaginary visit to different celestial spheres in the search, with descriptions of those visited, especially the more noteworthy of the fixed stars.

In turn the sun, the moon, Vega, Polaris, Capella, Arcturus, Regulus, Rigel and Canopus were described.

November 18.—The Society met at 8 p.m. in the Physics Building of the University of Toronto, the President, Mr. A. F. Miller, in the chair.

Prof. D. Buchanan, of Queen's University, Kingston, gave the address of the evening on "Astronomical Myths," illustrating the subject with a series of interesting lantern slides. With vivid imaginations the ancients had accomplished the grouping of the stars into constellations, and the lecture dealt mainly with the various myths regarding these, as they occur among primitive nations, with whom astronomy is always associated with religion. An ancient temple, especially one to Rā the Egyptian sun-god, shows orientation of its entrance door, into which the sunlight entering on one day in the year at sunrise, and shining along the axis of the temple, fell upon the altar and gave the first determination of the length of the year. Legends of the Great Bear, Orion, Canis Major, Hercules, the Pleiades, and other noteworthy constellations, were numerous, and marked the early development of astronomy. Interspersed with lantern slides showing the human figures and animals denoted by the constellations, on each of which was a skeleton diagram to show the positions of the chief stars, the lecturer showed some excellent photographs of nebulae, star clusters, and other similar astronomical phenomena.

The thanks of the audience was conveyed to the lecturer for his interesting address.

December 2.—The Society met in the Physics Building of the University of Toronto, Sir Robert Falconer in the chair, there being a large attendance of members and their friends.

The meeting was wholly devoted to the address by Dr. L. A. Bauer, Washington, D.C., on the Eclipse of May 29, 1919, and the researches of the Department of Terrestrial Magnetism of the Carnegie Institution. Dr. Bauer, in his introductory remarks, mentioned the work of Mr. H. F. Johnston and Mr. Andrew Thomson, in his department, both being graduates of the University of Toronto.

With Mr. Johnston he observed the total eclipse of May 29 last at Cape Palmas, Liberia, which is in North Latitude 6′ 33″, only a short way from the Equator. The duration of the eclipse at that place was the longest in his experience, being slightly more than six minutes. The wireless time signals from the Eiffel Tower at Paris, which he had been able to get on his way down the coast of Africa, were not appreciable so far south as Liberia. One of the subjects investigated during this eclipse was the effect of the eclipse on wireless signals, the British Admiralty assisting in this research. They found that during the eclipse there was improved action of the wireless, as strong as at night. The investigation which Dr. Bauer mainly carried out was that of terrestrial magnetism, for which the magnetic instruments were the chief apparatus carried by them. Conditions were particularly favorable to their work, as there was a larger shadow cone than usual. The phenomenon appeared much like an annular eclipse, as the inner corona was bright, and there was not as much darkness as expected owing to this fact. The largest prominence ever observed was visible during the eclipse, and there was also a remarkable corona. Besides photographs made at his station at Cape Palmas, he showed photographs of the eclipse from other places along the belt of totality, notably from the station occupied by Dr. A. C. D. Crommelin at Sobral, North Brazil, and from the station occupied by Prof. A. S. Eddington at Principe Island, off the coast of Africa. Dr. Bauer described the measurements of the positions of some stars from photographs taken during the eclipse by the foregoing observers, the deflections of the stars tending to verify Einstein's theory of relativity. Down to the seventh magnitude there were 13 stars in the field of view in the plates taken at the time, and it is claimed to have furnished a proof of the theory, which has also explained the motion of Mercury's perihelion. In addition to the lantern illustrations of the eclipse, and of places and scenes along the route to his station, Dr. Bauer showed a series of motion pictures of the "Carnegie" voyage of circumnavigation around the south polar cap. After a cordial vote of thanks, the meeting was adjourned.

A. F. HUNTER, *Recorder.*

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada
October, 1919

Temperature—The temperature was below the average throughout the Dominion, except in Ontario, where it was above from a line drawn from the extreme southeastern shores of Lake Superior, as far as or close to the eastern boundary of the Province. The negative departures were very pronounced in the Western Provinces and seemingly so over the northern portion of Canada generally.

Precipitation—In British Columbia the precipitation was much below average on Vancouver Island and over the Lower Mainland and above the average over the greater part of the Interior of the Province. In Alberta and Saskatchewan it exceeded the average, except quite locally. Manitoba was above generally. Ontario was well above the average in nearly all localities. Quebec was above over the western portion and much below elsewhere, while in the Maritime Provinces it was below, except in the very extreme southwest portion of Nova Scotia.

In the Western Provinces the precipitation was to a considerable extent snow. Snowfalls also occurred in British Columbia, in the northern parts of Ontario, and in Quebec and the Maritime Provinces, but they were as a rule quite local. The most marked positive departures in the precipitation were 3.22 inches at Barkerville, B.C., 2.95 inches at Ottawa, 2.19 inches at Montreal, and 1.54 inches at Edmonton, while the chief negative departures were 2.52 inches at Vancouver, 2.95 inches at Anticosti, 1.65 inches at Father Point, and 1.88 inches at Sydney, N.S.

TEMPERATURE FOR OCTOBER, 1919.

STATIONS	OCTOBER		STATIONS	OCTOBER	
	Highest	Lowest		Highest	Lowest
Yukon			*Ontario—continued*		
Dawson	44	− 6	Huntsville	78	21
British Columbia			Kenora	72	11
Atlin	57	2	Kinmount	—	—
Agassiz	68	20	Kingston	72	30
Barkerville	67	− 4	Kitchener	81	25
Kamloops	74	21	London	75	28
New Westminster	66	27	Lucknow	80	26
Prince Rupert	64	28	Markdale	75	27
Vancouver	62	27	North Gower	80	19
Victoria	67	32	Oshawa	69	32
Western Provinces			Ottawa	78	27
Battleford	69	−15	Paris	85	29
Calgary	74	− 7	Parry Sound	70	22
Edmonton	67	−15	Peterborough	82	22
Medicine Hat	78	− 6	Port Arthur	70	16
Minnedosa	68	−10	Port Burwell	—	—
Moosejaw	73	−13	Port Dover	84	30
Oakbank	75	− 1	Port Stanley	72	31
Portage la Prairie	76	4	Queensborough	73	22
Prince Albert	64	− 4	Ronville	72	25
Qu'Appelle	72	−14	Southampton	75	30
Regina	74	−15	Stonecliffe	72	10
Saskatoon	69	−14	Stoney Creek	85	32
Souris	72	−10	Toronto	80	32
Swift Current	75	−10	Uxbridge	76	25
Winnipeg	76	− 2	Wallaceburg	83	32
Ontario			Welland	82	30
Agincourt	79	30	White River	68	12
Aurora	76	28	*Quebec*		
Bancroft	73	21	Brome	72	16
Barrie	75	27	Father Point	60	22
Beatrice	73	22	Montreal	72	27
Bloomfield	72	27	Quebec	61	32
Brantford	85	31	Sherbrooke	71	19
Chapleau	62	20	*Maritime Provinces*		
Chatham	87	32	Charlottetown	64	26
Clinton	80	31	Chatham	62	20
Collingwood	80	29	Dalhousie	—	—
Cottam	95	29	Fredericton	65	17
Georgetown	82	31	Halifax	68	24
Goderich	—	—	Moncton	63	19
Gravenhurst	74	25	St. John	64	24
Grimsby	83	31	Sussex	64	19
Guelph	82	26	Sydney	66	28
Haliburton	76	18	Yarmouth	62	26

EARTHQUAKE RECORDS BY THE MILNE SEISMOGRAPH, TORONTO.

SIR FREDERIC STUPART, DIRECTOR.

P.T. = Preliminary Tremors. S. = Secondary Waves. L.W. = Large Waves. A.C. = Air Currents. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1919	P. T. Comm.	S. Comm.	L.W. Comm.	Max.	End.	Max. Amp.	Remarks.
		h m	h m	h m	h m	h m	h m	
	Oct. 1	Micros	on sheet	when other	station	records q	uake.	
2054	" 3		10?12. 6	10 32. 2 | 10 33. 6 /	10 39. 7	Micros.	1. 3	Times doubtful, watch under repairs.
2055	" 3			11 51. 8 | 11 59. 3 /	12?05. 9	Micros.	0. 3	Marked thickening.
2056	" 8			5 43. 8 | 5 52. 0 /	5 58. 6	6?58. 0	0. 3	Times doubtful, no cut-off.
2057	" 10			1 25. 9 | 1 27. 4 /	1 28. 0	2 12. 0	1. 3	Times very doubtful.
2058	" 12			23 10. 3	23 14. 6		0. 2	Times doubtful.
2059	" 21			22 32. 9	22 35. 5		0. 1	
2060	" 27	3?51. 1	3 59. 3	4 10. 5	4 12. 5	4 36. 5	0. 3	6680? km. Micros make initial phases doubtful.
2061	" 28			7 41. 7 | 7 48. 3 /	7 49. 2	7 54. 7	0. 2	

Period of Boom 18 seconds. Pillar inclination 1 mm = 0″.45.

VICTORIA, B.C.

F. NAPIER DENISON, SUPERINTENDENT.

No.	Date 1919	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks.
		h m s	h m s	h m s	h m s	h m s	mm.	
2047	Oct. 1	19 40 25			19 42 33	19 47 28	0. 2	
2048	" 3	10 00 29	10?13 51	10 18 41	10 27 32	11 11 18	0. 4	
2049	" 8	5?04 53		5 23 34	5 35 22	7 14 43	0. 8	
2050	" 10	1 08 1		1 09 00	1 09 30	2 54 14	1. 0	450 Km.
2051	" 12			23?09 48	23 11 16		0. 2	
2052	" 12				23 51 06	0 14 43	0. 2	
2053	" 14				12?04 32		0. 05	May not be seismic.
2054	" 21			22?09 15	22 15 09	22 32 51	0. 4	
2055	" 27			4 22 17 | 4 23 35 /		4 28 17	0. 1	Small but marked.

Period of Boom 18 seconds. Pillar inclination 1 mm. = 0″.54.

Magnetic Disturbances, October, 1919

During the month of October 1919, disturbances were of very frequent occurrence and some were of considerable magnitude. The accompanying table gives the time of occurrence and range of the larger ones.

These beginning on the 1st, 2nd, and 26th, were of the sudden commencement type and it is worthy of note that in the one on the 1st, which was the largest recorded during the month at Agincourt, there was recorded at Meanook the smallest range in Declination, although at the same time it exhibited very rapid and frequent changes of direction during the entire period of disturbance.

Brilliant displays of the aurora were reported on the 1st, 2nd, 15th, and 22nd, throughout Canada and lesser displays at some point in Canada every other night of the month but the 9th, which was full moon, and the 20th.

Sunspots were small and not very numerous with the exception of one group which was first observed on the 8th, and a second group on the 28th.

Date							Range			
Beginning				Ending			Agincourt. H	Agincourt. Z	Agincourt. D	Meanook D
		h	m			h m	γ	γ	° ′	° ′
Oct.	1.	11	10	Oct.	2.	4 —	859	585	2 9.5	1 14.7
"	2.	23	00	"	3.	19 —	427	414	1 11.8	2 34.4
"	4.	7	—	"	6.	7 —	503	419	2 22.5	2 52.9
"	15.	19	—	"	16.	9 —	231	181	0 46.9	2 50.9
"	22.	1	—	"	22.	14 —	167	42	0 31.8	3 05.5
"	22.	18	—	"	23.	13 —	316	300	1 49.9	2 22.1
"	26.	9	35	"	27.	10 —	207	149	1 05.9	3 55.8

W. E. W. J.

ASTRONOMICAL NOTES

VERIFICATION OF THE EINSTEIN THEORY OF RELATIVITY FROM THE ECLIPSE PHOTOGRAPHS

There are several items of astronomical interest this month. Foremost of course, is the report which comes from England, of the successful outcome of the observations made during the eclipse of last May to determine whether rays of light passing close to the sun are deflected from their course. This report affords one of the rare instances in which a topic of pure science assumes sufficient journalistic importance to justify cable despatches a column long; and in this case at least the real importance of the discovery is commensurate with the popular attention which is devoted to it.

The observed facts are easy enough to understand. At the time of the eclipse, the sun stood in a region of the heavens which is rich in bright stars—the Hyades, the well known cluster near the bright star, Aldebaran. When the sun's disc was obscured by the moon, these stars became visible, and could be photographed —the duration of totality being long enough to permit of several successive exposures. On the plates so obtained, the apparent positions of the stars could be accurately measured, and compared with those on other plates of the same regions taken when the stars were visible at night, remote from the sun. The comparison showed beyond question that those stars whose images fell near the occulted sun were apparently shifted in position, in comparison with the remoter stars in the field, which served as standards of reference—the shift being, in all cases, away from the sun's centre.

This taking and measuring of photographs of the stars is an everyday matter in observatories and the precautions necessary to insure accuracy are well known. The astronomers who are responsible for the present investigation—Prof. Eddington of Cambridge and Dr. Crommelin of Greenwich Observatory—are thoroughly familiar with work of this sort, and have undoubtedly taken every precaution to insure accuracy. Their conclusion that the shift of the star image actually occurs is accordingly unchallengeable.

What this discovery means is, obviously, that rays of light which pass near the sun are deflected towards it—so that looking back along the deflected rays toward the star, the latter appears to be shifted away from the sun. Crudely put, it is evident that the sun, and presumably any other large body, attracts passing waves of light and deviates their paths. The deviation is small, only 1¾ seconds of arc for a ray which has passed close to the sun; but it is twice as

great as the deflection which would be produced according to the familiar theory by the sun's attraction on the motion of a material particle moving past it with the velocity of light.

The most remarkable feature of the situation is that this deflection, both in direction and amount, has been predicted theoretically by Einstein, a physicist of Swiss birth, resident in Germany, who has long been recognized by students of mathematical physics to be worthy of the high place which will doubtless now be his by acclamation.

His theoretical discussions are far too complicated to speak of here: indeed, the mathematical developments are of so unfamiliar a nature that very few living men are competent to analyse them critically. But it may be possible to give some idea of the nature of the concepts which led to the development of his theory.

The theory of Relativity, which has excited the lively interest of physicists for some years past, and now appears to be firmly founded in fact, is based on the hypothesis that Nature is so constituted that it is impossible, by any physical experiment, to distinguish whether a given "system," including the observers, their instruments, and everything they can detect and observe, is at rest in space; or whether all parts of it are moving in the same direction and at the same rate. In both cases, the relative motions of the various parts of the system will be the same; and if the theory is true, only these can be the objects of physical investigations. Einstein, starting from this hypothesis, considered a further question which may be illustrated as follows. Assume an observer who, with all his instruments, is enclosed within a large, perfectly tight box, inside which he can live and work indefinitely. Now imagine, first, that the box and its contents are at rest in space (except in so far as he, in his experiments, sets various contained objects in relative motion). Second, suppose that the box and everything inside it are all falling freely in a uniform gravitational field (as bodies do near the earth's surface). Since the box and its contents are all falling at the same rate, the observer will not feel the pull of gravity, nor can he detect its existence by any experiment involving the motions of material bodies. But, according to the theory of light which was accepted until recently, the presence of the gravitational forces will not affect the motion of the light waves at all. If this is true, it ought to be possible, by suitably designed optical experiments, to detect the motion of the box and its contents in the second case. This would be true, even if the older theory of relativity were accepted, since the box with everything in it are not moving uniformly, but at an ever accelerating rate.

On the other hand it may be that the general principle or relativity applies even here, and that no experiment could detect anything beyond the relative motions of the contents of the box (including the waves of light). Einstein started with this latter assumption—which necessarily involved the belief that the motion of light is in some way affected by the presence of a gravitational field of force. Following out the consequences through the intricate analysis aforesaid, he reached the conclusion regarding the deflection of rays of light passing near the sun, which has just been so brilliantly confirmed by observation.

Two other natural phenomena (and only these two, as far as yet is known) should also be necessarily different according to the Einstein theory and the older one. Firstly, the elliptical orbit of a planet should not be quite fixed in space, but its perihelion should slowly advance, by an amount which can be definitely calculated. If there are other planets attracting this one, the purturbations due to their influence must of course be added. Now the perihelion of Mercury, after correction has been made for the effects of the attraction of the other planets, is actually moving forward in a manner not explicable by the classical theory, and to an extent about fifty times as great as the probable error of the observations. Now this "inexplicable" advance is found to take place at exactly the rate which has been predicted by Einstein's theory.

Secondly, his theory predicts that all the lines in the solar spectrum should be very slightly shifted towards the red, in comparison with the lines of the same elements, produced in terrestrial laboratories. This effect has been looked for, notably by Dr. St. John at Mount Wilson, and has not been found. There are, however, so many other things that may shift the lines in the sun's spectrum—pressure, currents in the sun's atmosphere, etc.—that this unfavorable evidence is not so strong as the positive and very favorable evidence of the two phenomena previously discussed.

At the present time, therefore, Einstein's theory appears to be very probable, if not altogether proved. Much is being said about the radical changes in our conceptions which will follow; but it is easy to exaggerate the significance of such remarks.

The central fact which has been proved—and which is of great interest and importance—is that the natural phenomena involving gravitation and inertia (such as the motions of the planets) and the phenomena involving electricity and magnetism (including the motion of light) are not independent of one another, but are intimately related, so that both sets of phenomena should be regarded as parts of one vast system, embracing all Nature. The relation of the two is, however, of such a character that it is perceptible only in a very few instances, and then only to refined observations.

The mathematical relations involved are most elegantly, and, to the trained mathematician, most simply expressed in terms of the non-Euclidean geometry, in which the properties of "parallel" lines are not those assumed by Euclid; and of space of four or even five dimensions. But these are only ways of expressing the facts, and ways that are likely to appear simple only to the trained mathematician. The important physical fact is the relation between gravitation and electro-magnetism, as explained above.—HENRY NORRIS RUSSELL in *Scientific American*.

MY THEORY.

The special relativity theory which was simply a systematic extension of the electro-dynamics of Maxwell and Lorentz, had consequences which reached beyond itself. Must the independence of physical laws with regard to a system of coordinates be limited to systems of coordinates in uniform movement of

translation with regard to one another? What has nature to do with the coordinate systems that we propose and with their motions? Although it may be necessary for our descriptions of nature to employ systems of coordinates that we have selected arbitrarily, the choice should not be limited in any way so far as their state of motion is concerned. (General theory of relativity.) The application of this general theory of relativity was found to be in conflict with a well-known experiment, according to which it appeared that the weight and the inertia of a body depended on the same constants (identity of inert and heavy masses). Consider the case of a system of coordinates which is conceived as being in stable rotation to a system of inertia in the Newtonian sense. The forces which, relatively to this system, are centrifugal must, in the Newtonian sense, be attributed to inertia. But these centrifugal forces are, like gravitation, proportional to the mass of the bodies. It is not, then, possible to regard the system of coordinates as at rest, and the centrifugal forces of gravitation? The interpretation seemed obvious, but classical mechanics forbade it.

This slight sketch indicates how a generalized theory of relativity must include the laws of gravitation, and actual pursuit of the conception has justified the hope. But the way was harder than was expected, because it contradicted Euclidian geometry. In other words, the laws according to which material bodies are arranged in space do not exactly agree with the laws of space prescribed by the Euclidian geometry of solids. This is what is meant by the phrase "a warp in space". The fundamental concepts "straight", "plane", etc., accordingly lose their exact meaning in physics.

In the generalized theory of relativity, the doctrine of space and time, kinematics, is no longer one of the absolute foundations of general physics. The geometrical states of bodies and the rates of clocks depend in the first place on their gravitational fields, which again are produced by the material systems concerned.

Thus the new theory of gravitation diverges widely from that of Newton with respect to its basal principle. But in practical application the two agree so closely that it has been difficult to find cases in which the actual differences could be subjected to observation. As yet only the following have been suggested:

1. The distortion of the oval orbits of planets round the sun (confirmed in the case of the planet Mercury).

2. The deviation of light-rays in a gravitational field (confirmed by the English Solar Eclipse expedition).

3. The shifting of spectral lines towards the red end of the spectrum in the case of light coming to us from stars of appreciable mass (not yet confirmed).

The great attraction of the theory is its logical consistency. If any deduction from it should prove untenable, it must be given up. A modification of it seems impossible without destruction of the whole.

No one must think that Newton's great creation can be overthrown in any real sense by this or by any other theory. His clear and wide ideas will for ever retain their significance as the foundation on which our modern conceptions of physics have been built.—ALBERT EINSTEIN in *The Times*, London, Eng.

J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

PROGRESS TOWARDS THE PROPOSED OBSERVATORY FOR TORONTO.

In the July-August issue (p. 299) is given an account of efforts being made to establish an astronomical observatory in Toronto. The chief features of the project were: (1) that the City should supply the site; (2) that the University should maintain the observatory; (3) that the Royal Astronomical Society should have accommodation for its various activities.

On June 11 last a deputation waited upon the Board of Control of the City and explained the nature of the project. It was favourably received and the Board requested that a committee be appointed to meet a committee of permanent city officials. Accordingly a committee, consisting of Messrs. A. F. Miller, John A. Paterson and J. R. Collins, representing the Society, and Messrs. A. T. DeLury, J. C. Robertson and C. A. Chant, representing the University, had a conference with the Commissioner of Finance, the Commissioner of Parks, the Assessment Commissioner and the City Solicitor; and a form of agreement was drawn up. This was reported to the Board of Control on August 6th. On November 26th the report was considered by the Board and approved, and on December 4th it was finally ratified by the City Council.

Its provisions are as follows:

1. The City shall dedicate the property *as shown on plan herewith*, as a park for the citizens.

2. The north-easterly portion, comprising approximately three acres, shall be leased for one dollar per year, to a Board of Trustees, composed of the Mayor of the City, the President of the University, and the President of the Royal Astronomical Society, the lease to run for forty-two years, and thereafter to be perpetually renewable for twenty-one-year periods at the same rate.

3. This Board shall facilitate the erection thereon within ten years of an Astronomical Observatory, according to plans which shall be approved by the City Architect and the Commissioner of Parks.

4. Should the land and buildings cease to be occupied by the Royal Astronomical Society and the University of Toronto, for the purposes herein specified, the same, together with all improvements, shall thereupon revert to, and become the property of the City, without any cost or charge, and may be used by it for such purposes as may then be determined.

5. The City shall maintain the park, and also any portion of the site allotted to the Observatory, which is not in actual use for the purposes of the observatory, the citizens being allowed the use of this unoccupied portion on the same conditions as obtain for the rest of the park.

6. No fence shall be erected upon the property, and no physical change shall be made thereto without first having obtained the consent of the City.

7. The University shall maintain the observatory. The Government of it shall be vested in a Board of Management, consisting of seven members. The Professor of Astronomy in the University shall be *ex officio* the Chairman of this Board, and three members shall be nominated annually by the Board of Governors of the University, two by the Council of the Astronomical Society, and one by the City.

8. The citizens shall be admitted to the observatory on conditions to be approved from time to time by the Board of Management.

9. The Royal Astronomical Society shall be provided with accommodation for its library, and for the storage of its instruments in the building.

10. The Society shall maintain the library, and shall allow the citizens to use it on conditions similar to those of the Toronto Public Library.

11. The Society shall have accommodation for its regular and general meetings, and on other occasions, as approved by the Board of Management.

The site is situated on the east side of Bathurst St., about half a mile north of St. Clair Avenue, and at present is not within the City limits. The entire property contains ten acres and it is well suited to the purpose in view. Now that the site is assured the Committee is endeavouring to discover some person or persons of means who will erect the building. As the one who does this will confer a peculiar favour upon the community and, at the same time, secure an honourable fame for himself through the discoveries which will be made at the observatory, it is confidently believed that the required funds will be forthcoming.

Appointment of Dr. Klotz

Dr. Otto Klotz, Director of the Dominion Observatory, Ottawa, has been appointed the representative of Canada on the "Committee on Magnetic Surveys, Charts and Secular Variation" of the International Geodetic and Geophysical Union, recently formed at Brussels.

The Kindness of Our Friends.

Most of the illustrations in this issue are from blocks generously loaned by *Popular Astronomy*, the *Astrophysical Journal* and the *Publications of the Astronomical Society of the Pacific*, to whom our thanks are given. We learn with regret, though not with surprise, that the first-named magazine finds it necessary to increase its subscription price. We hope this will not cause any to cease taking this admirable periodical. As for "our" Journal, we could not publish it were it not for grants received for the purpose, and even with this assistance the increased cost of publishing has made it difficult to print the material available. A doubling of our membership would relieve the stringency.

C. A. C.

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